# Allostatic Load and the Impact of Caregiving on the Health and Well-Being of Kenya Luo Grandparents:

A Senior Honors Thesis

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by

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**INTRODUCTION**

Allostasis and allostatic load are relatively new concepts, proposed to explain physiological responses to stress (McEwen 2003). Sterling and Eyer (1988) introduced allostasis, which is the ability of the body to change physiologically in response to a stressor in order to maintain overall somatic stability. Allostasis is an extension of the concept of homeostasis. Homeostasis aims to reduce variability, while with allostasis more variability is favorable because it means the internal environment has the capacity to adapt to various environmental challenges in support of the body's systems. In homeostatic systems, there exists a narrow physiological range indicative of health and any deviance from this range is an indication of disease. However, in allostatic systems, the normal range varies according to dynamic biological processes and variability is a healthy adaptive mechanism to environmental challenges (Karlamangla et al. 2002, McEwen 2002, Logan and Barksdale 2008).

The concepts of allostatic load (AL) and allostasis were developed to measure the effects of long-term exposure to stress on humans (McEwen 2003). AL refers to the accumulation of wear and tear on physiological systems from adaptive processes. Eventually, normal allostatic processes wear out and do not allow physiological systems to adapt to internal and external stressors and challenges. This wear and tear is a natural consequence of environmental adaptation. McEwen (2003) proposed that AL accumulates from an overactive or inefficiently managed allostatic system. AL potentially offers a comprehensive measure of long-term stress, however it was developed during studies of relatively affluent, high functioning elderly Western cohorts. AL provides a tool for investigating developmental and cumulative effects of life-long stress on human variation and senescence (Stewart 2006). The need for more cross-cultural research was detailed by Crews (2007).

Here, I use AL to estimate associations of physiological components of stress response with multiple variables in a sample of Kenyan grandparents. By combining a series of known risk factors for chronic degenerative conditions (CDC) into an estimate of stress load, I will determine how AL varies across this sample and associates with health, social, and physiological factors. Such studies in cross-cultural settings, ultimately allow us to conceptualize the importance and variability of stress responses of humans on disease and survival, major goals of anthropology and human biology (Ice and James 2007).

**Allostatic Load**

Allostatic load is the dynamic interplay of bodily systems in response to changing environments. According to McEwen (2003), allostatic load can accumulate in at least four ways-stressors can *hit* an organism repeatedly, resulting in a response. With continuous responses, the efficiency of each response may decline as the stress continues to occur. Also, if the allostatic system fails to end a response after stasis has been restored, wear and tear will accumulate (see McEwen 1999). Finally, some genotypes do not produce enough of a primary response hormone, causing damaging effects from lack of allostasis. Perceived stress, whether from an internal or external stressor, initiates an individual's physiological and behavioral responses. Constant response to changing stressors by the autonomic nervous system, the HPA axis, and pulmonary, cardiovascular, and immune systems leads to continual variation in adaptive physiological milieus (Sterling and Eyer, 1988; Schulken, 2003).

Allostatic responses are closely compatible with anthropological views of individual adaptability to environmental changes requiring constant physiological adjustments to maintain the soma (Crews, 2007). AL may be estimated using 10 physiological measures described as primary and secondary mediators of stress (Table 1, Crews, 2007; McEwen 1999, 2000; McEwen and Stellar, 1993; Seeman et al., 1997, 2001, 2004). Additional physiological measures, genetic markers, and social and economic factors will be needed to fully determine composite stress indexes (McEwen, 1999, 2000). AL varies across populations and samples and its assessment is based upon the distinctive distribution of risk factors within each population (Crews 2007). Each ecological setting has different stressors and different people respond differently to the same stressor (Ice and James 2007). Thus, adaptability and AL differ within and between populations.

Table 1: The components of allostatic load after McEwen (1999)

| |
|---|
| *Secondary Mediators of Stress:* |
| Systolic and diastolic blood pressure |
| Waist/hip ratio |
| HDL-cholesterol and total-cholesterol |
| Glycated hemoglobin |
| *Primary Mediators of Stress:* |
| Serum dihydroepiandosterone – sulfate |
| Overnight urinary cortisol, adrenaline, noradrenaline |

**Caregivers in Africa**

The HIV/AIDS pandemic is particularly harsh in areas of Africa (UNAIDS, 2006). As this crisis continues, the number of orphaned children being cared for by their grandparents has increased, creating a tremendous economic and social burden. Caregiving has the potential to impact health of elders as an economic stressor and/or as a psychosocial stressor (Ice et al., 2010). In most cases, these grandparents have increasing responsibilities, which are believed to make elders more vulnerable to ill health and disease. Caregiving is an established chronic stressor and many studies have examined its relationship to health and its effect on physiological systems (Agyarko, Kalache, and Kowal, 2000; Minkler and Fuller-Thompson 1999, 2001; Musil and Ahmad, 2002). Unfortunately, most of what is known is based on small case reports with very few studies outside of the U.S, and often lack objective measures of health or a comparison group.

### PREVIOUS RESULTS

Data from previous research shows few differences in health between the two groups, caregivers and non-caregivers, examined in the Luo of Kenya (Ice et al., 2010). Where differences were observed, caregivers were more likely to have *better* perceived general and mental health (Ice et al., 2010). Among this Luo sample from Kenya, neither a simple nor a distinct relationship existed between caregiving and overall general health. It appears that caregiving status by itself does not appear to be a sufficiently strong psychosocial or economic stressor to impact objectively measured health (Ice et al., 2010). None of the measured biomarkers of health were closely associated with caregiving status. As part of a longitudinal study conducted by Ice and colleagues, variables to measure and compute allostatic load analyses are available to assess physiological effects of caregiving on AL in African grandparents and whether AL influences health of caregivers. In this study, differences in AL between caregivers and non-caregivers are examined, as are differences in AL across income, social status, and education level.

## MATERIALS AND METHODS

### DATA

In 2005, Dr. Gillian H. Ice's research team from Ohio University and Kenya initiated a longitudinal study in 18 centers from three districts of Nyanza Province, Kenya. These centers represented 18 different villages within these three districts. Data were obtained over three waves of measurements between 2005 and 2007. To measure and compute AL and assess its physiological effects, we examined data obtained in 2006. A non-random sample of non-caregivers and caregivers over 60 years of age was enlisted. To be considered a caregiver, a participant was over 60 years old, a grandparent, and primary caregiver for at least one orphaned grandchild. Non-caregivers were persons over the age of 60 years who were grandparents, but were not the primary caregiver for any orphaned grandchildren. Each caregiver's status was determined during interviews regarding household composition. The primary hypotheses guiding this research were that caregivers would have poorer health than non-caregivers and that caregiving would increase risks for chronic degenerative conditions (CDC) and cardiovascular disease (CVD) (Ice et al., 2010). CVD risk was assessed using Framingham risk scores.

Data were obtained at a central location in each village. The questionnaire included demographic information, household composition, individual caregiving history, intensity of caregiving and burden, social support, and information on general wealth. Ten anthropometric measurements were completed (Ice et al., 2010). Height and weight were used to calculate body mass index. BMI = ( weight (kg) / height ($m^2$) ), which was determined for all participants. Skinfolds (triceps, subscapular, suprailiac and calf) and circumferences also were measured (arm, waist, hip and calf). In addition, saliva was obtained to assess cortisol. Waist and hip circumferences were used to determine the waist-hip ratio. Blood was collected by fingerprick to assess total cholesterol, HDL (high-density lipoprotein) cholesterol, glycated hemoglobin (Hb $A_{1\text{-}C}$) and fasting glucose. Smoking history was self-reported. The Framingham study's coronary disease risk predictor score sheets were used to calculate the risk of developing cardiovascular disease within the next 10 years for caregivers and non-caregivers (Lloyd-Jones et al., 2004). Participants' age, total cholesterol, HDL cholesterol, blood pressure, diabetes, sex, and smoking history were assigned a value based on the Framingham study results.

**ALLOSTASIS AND ALLOSTATIC LOAD**

To determine AL, a composite model of psycho-physiological and physical stress is examined. For this study we examined data for systolic and diastolic blood pressure, waist/ hip ratio (w/h= (waist (cm)/ hip (cm)) X 100) to measure trunk obesity, HDL-cholesterol, total cholesterol, cortisol, and glucose as our AL mediators for the 2006 sample. Following McEwen et al. (2000), stress scores for individuals are calculated by scoring all measures as 1 for the highest quartile of risk and 0 for the 3 lower risk quartiles. These are summed across all measures resulting in a score for each individual that ranges from zero to the number of variables examined-seven variables for our sample. Generally, the highest quartile is scored 1 for all measures included in assessing AL, except HDL for which highest risks occur at lower levels. For HDL, the lowest quartile is scored 1 (see McEwen, 2000; Crews, 2007). In the composite stress load model, individuals having the same total AL score may have very different risk profiles; also an individual's AL score changes over their life course (see Crews, 2007; McEwen 1999 & 2000; McEwen and Stellar, 1993; Seeman et al., 1997, 2001, 2004). We do not examine change in AL with time in these analyses.

**STATISTICAL METHODS**

We use this composite stress model to assess the influence of multiple variables on stress and of stress on outcome measures. First, AL stress scores and 22 other variables are compared between men and women to determine how they differ. Next, we use regression models to estimate the dependence of AL stress scores on age, sex, SES, function, mental health, physical roles, social roles, vitality, general health, pain scale, number of orphans, Framingham scores, available resources, support system, education, anxiety, despair, marital unions, caregiving, caregiving intensity and burden, and of nutritional factors such as calories, fat, carbohydrates, and protein.

**RESULTS:**

First we explored data on differences in AL and 22 other variables by sex (Table 2). The women sampled were older, had significantly lower levels of total cholesterol, and reported higher levels of mental and general health, vitality, and the ability to function and perform physical and social roles. Women also reported higher levels of pain, in addition to more education, resources, and support available to them. Men reported significantly higher levels of anxiety and despair. There were no significant differences in allostatic load scores between men and women. This result allowed us to combine both sexes for further analysis.

Next we ran a regression with AL against each one of these factors individually, reducing the number of variables in the model. In this analysis, AL was significantly associated with sex, Framingham scores, anxiety, and despair (Table 3). Regression was then used to estimate the dependence of stress loads on these four variables jointly. This reduced the number of significant variables to only two Framingham scores and sex (Table 4). Our final regression included this reduced number of variables. We found that for every unit increase in Framingham score AL increases by 1.25 points, explaining 20.7% of the variation in AL (Table 5).

**DISCUSSION**

From this sample it appears that AL is not strongly associated with age, sex, SES, mental health, physical roles, social roles, vitality, general health, pain scale, number of orphans, Framingham scores, available resources, support system, education, anxiety, despair, marital unions, caregiving, caregiving intensity and burden, and nutritional factors. Only the

Framingham score used to determine CV risk appears significantly associated with AL. However, the Framingham score has not been validated for this context, as it is only suggested that the score may be applicable to diverse populations (Ice et al., 2010). Results reported here may be confounded by various factors. Data from previous research shows that where differences were observed, caregivers were more likely to have better perceived general and mental health. Observed differences in caregiving status suggest that caregivers are healthier because those in ill health may not be capable of caring for children. In our model, none of the biomarkers of health were affected by caregiving status, suggesting that caregiving as a stressor either does not impact health or takes longer than three years to impact physical health (Ice et al., 2010). The better mental and perceived health of caregivers may decline over time and may eventually lead to poorer physical health outcomes. The small sample size could also limit the study and may have contributed to non-significant results.

These results are contrary to much of the literature on caregiving, which suggests that caregiving results in poorer health. Many earlier studies focused on subjective measures of health that failed to correspond to objective findings (Ice et al., 2010). While our findings do not find significant associations between AL and multiple outcome measures, it is vital to continue allostatic load research across populations. This methodology will continue to be useful investigating how stressful events and physiological stress may alter allostatic physiological responses.

Table 2: Differences between sexes on multiple variables and allostatic load scores

| | Male | Female | Difference | 95% CI | P-Value |
|---|---|---|---|---|---|
| *Age* | 72.3 | 74.1 | 1.8 | 0.27->3.27 | 0.021 |
| *SBP* | 132.8 | 130.6 | -2.2 | -7.3->2.97 | 0.41 |
| *DBP* | 76.8 | 77.6 | 0.84 | -1.9->3.6 | 0.55 |
| *Glucose* | 99.6 | 97.3 | -2.3 | -8.4->3.7 | 0.44 |
| *Total Cholesterol* | 155.8 | 140.8 | -15.0 | -21.9->-8.06 | 0.00 |
| *HDL* | 45.7 | 44.9 | -0.81 | -3.6->2.0 | 0.57 |
| *Mental Health* | 20.1 | 21.7 | 1.6 | .804->2.45 | 0.00 |
| *Function* | 18.7 | 21.0 | 2.3 | 1.28->3.34 | 0.00 |
| *Physical Roles* | 4.55 | 4.86 | 0.31 | 0.08->.54 | 0.009 |
| *Social Roles* | 3.41 | 3.64 | 0.23 | 0.032->.434 | 0.023 |
| *Vitality* | 8.60 | 9.50 | 0.88 | 0.45->1.31 | 0.00 |
| *General Health* | 17.96 | 18.93 | 0.97 | 0.47->1.46 | 0.00 |
| *Pain Scale* | 3.35 | 3.70 | 0.35 | 0.17->0.54 | 0.00 |
| *Framingham* | 0.308 | 0.304 | -0.004 | -0.106->.098 | 0.941 |
| *Resources* | 0.68 | 1.22 | 0.55 | 0.21->0.89 | 0.002 |
| *Support* | 5.2 | 6.3 | 1.1 | 0.42->1.8 | 0.002 |
| *Education* | 0.14 | 0.67 | 0.53 | 0.45->0.61 | 0.00 |
| *Waist* | 81.5 | 81.7 | 0.23 | -1.79->2.25 | 0.82 |
| *Hip* | 93.8 | 93.5 | -0.34 | -2.25->1.56 | 0.72 |
| *Waist/Hip* | 0.87 | 0.88 | 0.01 | -0.01->0.02 | 0.47 |
| *Anxiety* | 20.3 | 19.1 | -1.22 | -2.18->-0.269 | 0.012 |
| *Despair* | 18.5 | 17.3 | -1.19 | -2.15->-0.221 | 0.016 |
| *AL* | 1.74 | 1.67 | -.075 | -.333->1.83 | 0.569 |

Table 3: Association of allostatic load with individual variables

| *Dependent V* | $R^2$ | *Beta* | *P-Value* |
|---|---|---|---|
| *Age* | 0 | -0.002 | 0.989 |
| *Sex* | 0.076 | -0.276 | 0.067 |
| *Function* | 0.025 | 0.159 | 0.296 |
| *Mental Health* | 0.039 | 0.197 | 0.195 |
| *Physical Roles* | 0.027 | -0.164 | 0.28 |
| *Social Roles* | 0.008 | 0.089 | 0.562 |
| *Vitality* | 0.018 | -0.133 | 0.385 |
| *Gen Health* | 0.06 | 0.244 | 0.106 |
| *Pain Scale* | 0.005 | -0.068 | 0.656 |
| *Orphans* | 0.043 | 0.207 | 0.172 |
| *Framingham* | 0.084 | 0.289 | 0.054 |
| *Resources* | 0.015 | -0.121 | 0.429 |
| *Support* | 0.001 | -0.03 | 0.847 |
| *Education* | 0.003 | -0.053 | 0.732 |
| *Anxiety* | 0.114 | -0.337 | 0.023 |
| *Despair* | 0.09 | -0.3 | 0.045 |
| *Caregiver* | 0.009 | 0.093 | 0.545 |
| *Marital Union* | 0 | -0.001 | 0.992 |
| *SES* | 0.004 | 0.061 | 0.513 |
| *Intensity* | 0.014 | 0.118 | 0.203 |
| *Burden* | 0.01 | 0.098 | 0.289 |
| *Calories* | 0.001 | 0.033 | 0.719 |
| *Protein* | 0.006 | 0.078 | 0.402 |
| *Carbohydrates* | 0 | -0.018 | 0.848 |
| *Fat* | 0.01 | 0.099 | 0.285 |

Table 4: Association of allostatic load with joint variables

| *Dependent V* | *Beta* | *P-Value* |
|---|---|---|
| *Sex* | -.077 | .136 |
| *Framingham* | .453 | 0.000 |
| *Anxiety* | -.113 | .219 |
| *Despair* | .088 | .342 |

Table 5: Final regression with allostatic load and two variables

| *Dependent V* | $R^2$ | *Beta* | *P-Value* |
|---|---|---|---|
| *Sex* | - | -.077 | .178 |
| *Framingham* | .207 | .453 | 0.000 |

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